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**NASA**

# SPACE SHUTTLE MISSION STS-32

## PRESS KIT



# DECEMBER 1989

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## SYNCOM IV DEPLOY, LDEF RETRIEVAL HIGHLIGHT 10- DAY COLUMBIA FLIGHT

Highlights of Space Shuttle mission STS-32, the 33rd flight of the National Space Transportation System, will be deployment of a Navy synchronous communications satellite (Syncom IV) and retrieval of the Long Duration Exposure Facility (LDEF) launched aboard Challenger on mission STS-41C in April 1984.

Syncom IV-F5 is the last in a series of five Navy satellites built by Hughes Communications Services Inc. It is designed to provide worldwide, high-priority communications between aircraft, ships, submarines and land-based stations for the U.S. military services and the Presidential Command Network. Syncom measures 15 feet long and 13 feet in diameter.

After Syncom deployment using the "Frisbee" method, the crew will do a Shuttle separation burn maneuver away from the satellite. A solid rocket perigee kick motor along with several liquid apogee motor firings will boost the satellite to geosynchronous orbit.

The LDEF, a 12-sided, open-grid structure made of aluminum rings and longerons, is 30 feet long, 14 feet in diameter and

## STS-32 QUICK LOOK

**Launch Date and Site:** Dec. 18, 1989  
Kennedy Space Center, Fla. Pad 39-A.

**Launch Window:** 6:46 p.m. - 7:48 p.m. EST

**Orbiter:** Columbia (OV-102)

**Orbit:** 190 nm altitude; 28.5 degrees inclination

**Landing Date/Time:** Dec. 28, 1989/4:21 p.m. EST

**Primary Landing Site:** Edwards AFB, Calif.

### Abort Landing Sites:

Return to Launch Site - Kennedy Space Center  
Transoceanic Abort Landing - Ben Guerir, Morocco  
Abort Once Around - Edwards AFB

### Crew:

Daniel C. Brandenstein, Commander  
James D. Wetherbee, Pilot  
Bonnie J. Dunbar, Mission Specialist  
Marsha S. Ivins, Mission Specialist  
G. David Low, Mission Specialist

### Cargo Bay Payloads:

Syncom IV-F5 (primary payload); RMS for LDEF Retrieval

### Middeck Payloads:

Characterization of Neurospora Circadian Rhythms (CNCR)  
Protein Crystal Growth (PCG)  
Fluid Experiment Apparatus (FEA)  
American Flight Echocardiograph (AFE)  
Latitude/Longitude Locator (L3)  
IMAX

weighs 8,000 pounds. Retrieval of the LDEF will be accomplished by the orbiter's remote manipulator system (RMS) arm. Once the rendezvous portion of the mission is completed, Mission Specialist Bonnie Dunbar will grapple the LDEF with the end effector of the RMS and maneuver LDEF into the five support trunnion latches in the payload bay of Columbia.

The LDEF experiments range in research interest from materials to medicine to astrophysics. All required free-flying exposure in space without extensive electrical power, data handling or attitude control systems. Many of the experiments are relatively simple with some being completely passive while in orbit. The structure was designed for reloading and reuse once returned to Earth.

Orbital data on the LDEF is provided to NASA by the North American Aerospace Defense Command (NORAD). Intensive C-band radar tracking will begin approximately 72 hours before launch to provide the accurate data required for orbiter and LDEF rendezvous.

Joining Syncom IV—and later LDEF—in the payload bay of Columbia will be the Interim Operational Contamination Monitor (IOCM). This is an automatic operation system for the measurement of contamination that may be present in the payload bay for the entire mission duration. It is designed to provide continuous measurement of collected particulate and molecular mass at preprogrammed collection surface temperatures.

Columbia also will carry several secondary payloads involving material crystal growth, microgravity protein crystal

growth, lightning research, in-flight cardiovascular changes and effects of microgravity and light on the cellular processes that determine circadian rhythms and metabolic rates.

Commander of the mission is Daniel C. Brandenstein, Captain, USN. James D. Wetherbee, Lieutenant Commander, USN, is pilot. Brandenstein was pilot on mission STS-8 in August 1983 and commander of STS-51G in June 1985. Wetherbee will be making his first Shuttle flight.

Mission specialists are Bonnie J. Dunbar, Ph.D; Marsha S. Ivins and G. David Low. Dunbar previously flew as a mission specialist on STS-61A in October 1985. Ivins and Low will be making their first Shuttle flights.

Liftoff of the ninth flight of Columbia is scheduled for 6:46 p.m. EST on December 18 from Kennedy Space Center, Fla., launch pad 39-A, into a 190-nautical mile, 28.5 degree orbit.

A final decision on launch time will be made approximately 12 hours prior to launch. The decision will be based on the latest tracking data for the LDEF and allow for appropriate adjustment of Orbiter inflight computers.

Nominal mission duration is expected to be 9 days, 21 hours 35 minutes. Deorbit is planned on orbit 158, with landing scheduled for 4:21 p.m. EST, depending on actual launch time, on December 28 at Edwards Air Force Base, Calif.

The launch window for this mission is dictated by vehicle performance, real-time LDEF rendezvous data and the reentry track of the external tank.

## GENERAL INFORMATION

### NASA Select Television Transmission

NASA Select television is available on Satcom F-2R, Transponder 13, located at 72 degrees west longitude.

The schedule for orbiter transmissions and change-of-shift briefings from Johnson Space Center, Houston, will be available during the mission at Kennedy Space Center, Fla.; Marshall Space Flight Center, Huntsville, Ala.; Johnson Space Center; and NASA Headquarters, Washington, D.C. The schedule will be updated daily.

Schedules also may be obtained by calling COMSTOR, 713/483-5817. COMSTOR is a computer data base service requiring the use of a telephone modem. A voice update of the TV schedule may be obtained by dialing 202/755-1788. This service is updated daily at noon EST.

### Special Note to Broadcasters

In the five workdays before launch, short sound bites of STS-32 crew interviews will be available by calling 202/755-1788 between 8 a.m. and noon.

### Status Reports

Status reports on countdown, mission progress and landing operations will be produced by the appropriate NASA news center.

### Briefings

A press-briefing schedule will be issued before launch. During the mission, flight control personnel will be on 8-hour shifts. Change-of-shift briefings by the off-going flight director will occur at approximately 8-hour intervals.

## LAUNCH PREPARATIONS, COUNTDOWN AND LIFTOFF

Processing of Columbia for the STS-32 mission began on Aug. 21, when the spacecraft was towed to Orbiter Processing Facility (OPF) Bay 2 after arrival from Dryden Flight Research Facility. Post-flight deconfiguration of STS-28, Challenger's previous mission, and inspections were conducted in the hangar.

Approximately 26 modifications have been implemented since the STS-28 mission. One of the more significant added a fifth tank set for the orbiter's power reactant storage and distribution system. This will provide additional liquid hydrogen and liquid oxygen, which combine in the fuel cells to produce electricity for the Shuttle and water as a by-product. With the addition of the fifth tank, the mission duration has been planned for 10 days.

Improved controllers for the water spray boilers and auxiliary power units were also installed. Other improvements were made to the orbiter's structure and thermal protection system, mechanical systems, propulsion system and avionics system.

Columbia was transferred from the OPF to the Vehicle Assembly Building (VAB) on Nov. 16 for mating to the external tank and SRBs. The assembled Space Shuttle was rolled out of the VAB aboard its mobile launcher platform (MLP) for the 3.4-mile trip to Launch Pad 39-A on Nov. 28. STS-32 will mark the first use of MLP-3 in the Shuttle program and the first use of Pad A since mission 61-C in January 1986.

The countdown for Columbia's ninth launch will pick up at T-minus 43-hours. The launch will be conducted by a NASA-and-industry team from Firing Room 1 in the Launch Control Center.

## SPACE SHUTTLE ABORT MODES

Space Shuttle launch abort philosophy aims for safe and intact recovery of the flight crew, the orbiter and its payload. Abort modes include:

- **Abort-To-Orbit (ATO):** Partial loss of main engine thrust late enough to permit reaching a minimal 105-nautical-mile orbit with orbital maneuvering system engines.
- **Abort-Once-Around (AOA):** Earlier main engine shutdown with the capability to allow one orbit around before landing at Edwards Air Force Base, Calif.; White Sands Space Harbor (Northrup Strip), N.M.; or the Shuttle Landing Facility (SLF) at Kennedy Space Center, Fla.
- **Trans-Atlantic Abort Landing (TAL):** Loss of two main engines midway through powered flight would force a landing at Ben Guerir, Morocco; Moron, Spain; or Banjul, The Gambia.
- **Return-To-Launch-Site (RTL):** Early shutdown of one or more engines and without enough energy to reach Ben Guerir, would result in a pitch around and thrust back toward KSC until within gliding distance of the SLF.

STS-32 contingency landing sites are Edwards AFB, White Sands, Kennedy Space Center, Ben Guerir, Moron and Banjul.

## MAJOR COUNTDOWN MILESTONES

### **T-43 Hours (43:00:00)**

- Verify that the Space Shuttle is powered up.

### **T-34:00:00**

- Continue orbiter and ground support equipment closeouts for launch.

### **T-30:00:00**

- Activate orbiter's navigation aids.

### **T-27:00:00 (holding)**

- Enter the first built-in hold for eight hours.

### **T-27:00:00 (counting)**

- Begin preparations for loading fuel cell storage tanks with liquid oxygen and liquid hydrogen reactants.

### **T-25:00:00**

- Load the orbiter's fuel cell tanks with liquid oxygen.

### **T-22:30:00**

- Load the orbiter's fuel cell tanks with liquid hydrogen.

### **T-22:00:00**

- Perform interface check between Houston Mission Control and the Merritt Island Launch Area (MILA) tracking station.

### **T-20:00:00**

- Activate inertial measurement units (IMUs).

**T-19:00:00 (holding)**

- Enter the 8-hour built-in hold.
- Activate orbiter communications system.

**T-19:00:00 (counting)**

- Resume countdown.
- Continue preparations to load the external tank, orbiter closeouts and preparations to move the Rotating Service Structure.

**T-11:00:00 (holding)**

- Start built-in hold, duration dependent on launch time.
- Perform orbiter ascent switch list in the orbiter flight and middecks.

**T-11:00:00 (counting)**

- Retract Rotating Service Structure from vehicle to launch position. (Could occur several hours earlier if weather is favorable.)

**T-9:00:00**

- Activate orbiter's fuel cells.

**T-8:00:00**

- Configure Mission Control communications for launch.
- Start clearing blast danger area.

**T-6:30:00**

- Perform Eastern Test Range open loop command test.

**T-6:00:00 (holding)**

- Enter one-hour built-in hold. Receive mission management "go" for tanking.

**T-6:00:00 (counting)**

- Start external tank chilldown and propellant loading.

**T-5:00:00**

- Start IMU pre-flight calibration.

**T-4:00:00**

- Perform MILA antenna alignment.

**T-3:00:00 (holding)**

- Begin two-hour built-in hold.
- Complete external tank loading and ensure tank is in a stable replenish mode.

- Ice team goes to pad for inspections.

- Closeout crew goes to white room to begin preparing orbiter's cabin for flight crew's entry.

- Wake flight crew (actual time launch minus 4:55:00).

**T-3:00:00 (counting)**

- Resume countdown.

**T-2:55:00**

- Flight crew departs O&C Building for Launch Pad 39-A (Launch minus 3:15:00).

**T-2:30:00**

- Crew enters orbiter vehicle (Launch minus 3:15:00).

**T-00:60:00**

- Start pre-flight alignment of IMUs.

**T-00:20:00 (holding)**

- 10-minute built-in-hold begins.

**T-00:20:00 (counting)**

- Configure orbiter computers for launch.

**T-00:10:00**

- White room closeout crew cleared through the launch danger area roadblocks.

**T-00:09:00 (holding)**

- Begin 10-minute built-in-hold.
- Perform status check and receive Launch Director and Mission Management Team "go."

**T-00:09:00 (counting)**

- Start ground launch sequencer.

**T-00:07:30**

- Retract orbiter access arm.

**T-00:05:00**

- Pilot starts auxiliary power units.
- Arm range safety, SRB ignition systems.

**T-00:03:30**

- Place orbiter on internal power.

**T-00:02:55**

- Pressurize liquid oxygen tank for flight and retract gaseous oxygen vent hood.

**T-00:01:57**

- Pressurize liquid hydrogen tank.

**T-00:00:31**

- "Go" from ground computer for orbiter computers to start the automatic launch sequence.

**T-00:00:28**

- Start solid rocket booster hydraulic power units.

**T-00:00:21**

- Start SRB gimbal profile test.

**T-00:00:06.6**

- Main engine start.

**T-00:00:03**

- Main engines at 90 percent thrust.

**T-00:00:00**

- SRB ignition, aft skirt holddown post release and liftoff.
- Flight begins and control switches to Houston.



## TRAJECTORY SEQUENCE OF EVENTS

EVENT	MET (d/h:m:s)	RELATIVE VELOCITY (fps)	MACH	ALT. (ft)
Launch	00/00:00:00			
Begin Roll Maneuver	00/00:00:09	159	.14	604
End Roll Maneuver	00/00:00:15	311	.28	2,165
SSME Throttle Down to 65 percent	00/00:00:28	663	.61	8,313
Max. Dyn. Pressure (Max Q)	00/00:00:52	1,171	1.10	26,751
SSME Throttle Up to 104 percent	00/00:00:59	1,323	1.27	33,602
SRB Staging	00/00:02:06	4,138	3.75	157,422
Negative Return	00/00:04:05	7,100	7.61	339,500
Main Engine Cutoff (MECO)	00/00:08:34	24,543	22.88	362,696
Zero Thrust	00/00:08:40	24,557	22.59	364,991
ET Separation	00/00:08:52			
OMS 2 Burn	00/00:40:27			
Syncom IV-F5 Deploy (orbit 17)	01/00:44:00			
Deorbit Burn (orbit 158)	09/20:38:17			
Landing (orbit 159)	09/21:34:44			

Apogee, Perigee at MECO: 186 x 34

Apogee, Perigee at post-OMS 2: 190 x 160\*

Apogee, Perigee at post-deploy: 190 x 166\*

\*These numbers are highly variable depending on real-time LDEF altitude at time of launch.

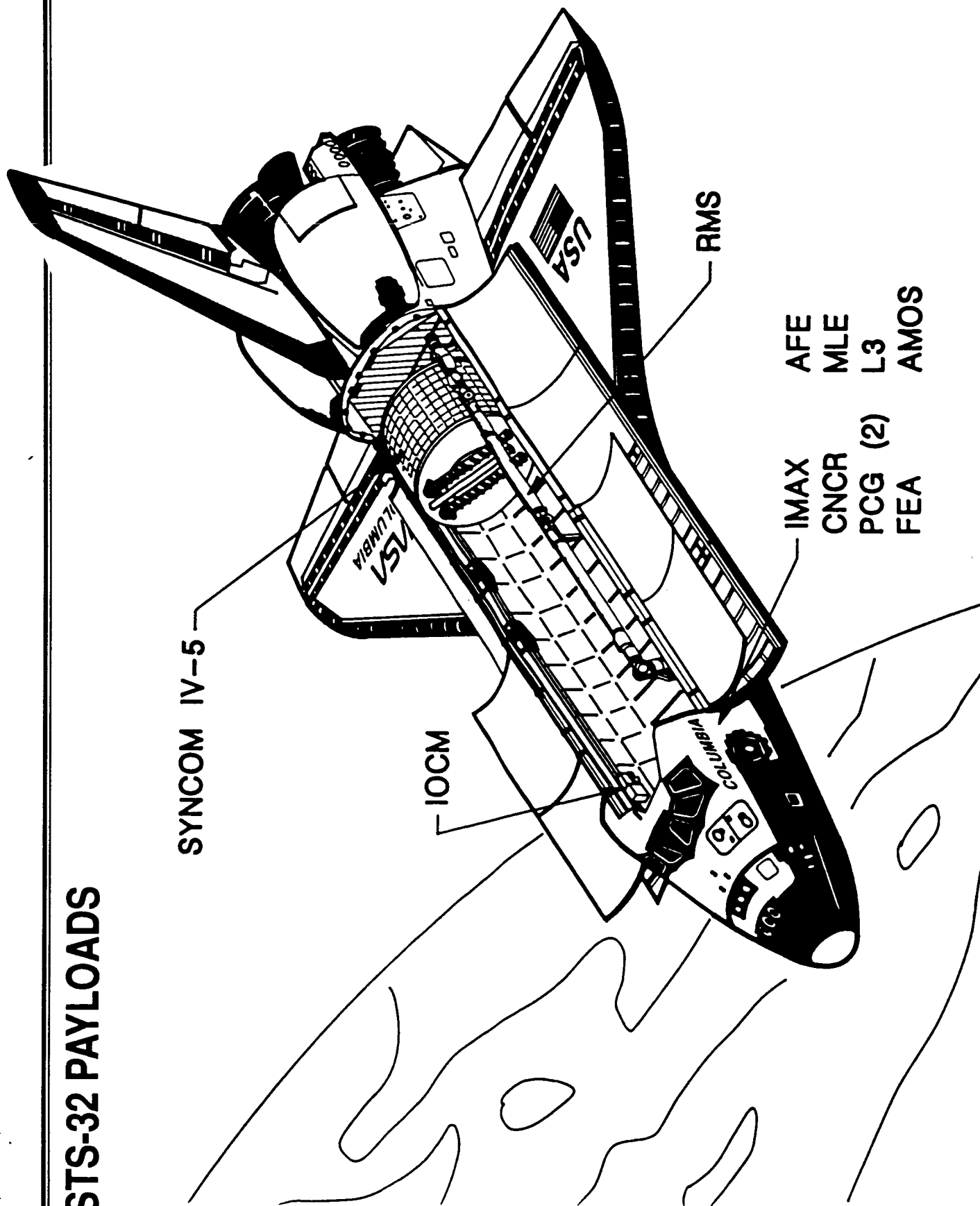
## Vehicle and Payload Weights

Orbiter (Columbia) Empty	Pounds 185,363
Remote Manipulator System (payload bay)	858
Syncom IV-5 (payload bay)	5,286
Syncom ASE	1801
Long Duration Exposure Facility (LDEF)	21,393
Interim Operational Contamination Monitor (IOCM))	137
American Flight Echocardiograph (AFE)	111
Characterization of Neurospora Circadian Rhythms (CNCR)	43
Detailed Secondary Objectives (DSO)	163
Detailed Technical Objectives (DTO)	36
Fluids Experiment Apparatus (FEA)	148
IMAX Camera	274
Latitude-Longitude Locator (L3)	56
Mesoscale Lightning Experiment (MLE)	15
Protein Crystal Growth Experiment (PCG)	154
Orbiter and Cargo at SRB Ignition	256,670
Total Vehicle at SRB Ignition	4,523,534
Orbiter Landing Weight	229,526

## Summary of major activities

<b>Day One</b> Ascent Post-insertion checkout Unstow cabin RMS checkout AFE CNCR DSO FEA unstow PCG activation	<b>Day Five</b> AFE DSO FEA L3 setup IMAX
<b>Day Two</b> Syncom IV deploy AFE DSO/DTO FEA IMAX	<b>Day Six</b> AFE DSO/DTO FEA IMAX
<b>Day Three</b> Syncom backup deploy/injection AFE DSO/DTO FEA IMAX	<b>Day Seven</b> AFE DSO/DTO FEA IMAX
<b>Day Four</b> LDEF rendezvous LDEF grapple LDEF photo survey LDEF berthing LDEF deactivation AFE DTO FEA IMAX	<b>Day Eight</b> AFE DSO/DTO FEA stow IMAX
	<b>Day Nine</b> AFE stow DSO/DTO FCS checkout IMAX stow L3 stow PCG deactivation Cabin stow Landing preparations
	<b>Day 10</b> Deorbit preparations and burn Landing at Edwards AFB

# STS-32 PAYLOADS



## LANDING AND POST-LANDING OPERATIONS

The Kennedy Space Center is responsible for ground operations of the orbiter once it has rolled to a stop on the runway at Edwards Air Force Base. Those operations include preparing Columbia for the return trip to Kennedy.

After landing, the flight crew aboard Columbia begins "safing" vehicle systems. Immediately after wheels stop, specially garbed technicians will first determine that any residual hazardous vapors are below significant levels in order for other safing operations to proceed.

A mobile white room is moved into place around the crew hatch once it is verified that there are no concentrations of toxic gases around the forward part of the vehicle. The flight crew is expected to leave Columbia about 45 to 50 minutes after landing. As the crew exits, technicians will enter the orbiter to complete the vehicle safing activity.

Pending completion of planned work and favorable weather conditions, the 747 Shuttle Carrier Aircraft would depart California about 6 days after landing for the cross-country ferry flight back to Florida. Several refueling stops will be necessary to complete the journey because of the weight of the LDEF payload.

Once back at Kennedy, Columbia will be pulled inside the hangar like processing facility where the retrieved Long Duration Exposure Facility (LDEF) will be removed from the payload bay. Orbiter post-flight inspections, in-flight anomaly trouble-shooting and routine systems reverification will commence to prepare Columbia for its next mission.

## STS-32 PAYLOADS

### SYNCOM IV-F5

Syncom IV-F5, also known as LEASAT 5, will be the fourth operational satellite in the LEASAT system. It will be leased by the Department of Defense to replace the older FleetSatCom spacecraft for worldwide UHF communications between ships, planes and fixed facilities. A Hughes HS381 design, the LEASAT spacecraft is designed expressly for launch from the Space Shuttle and uses the unique "Frisbee," or rollout, method of deployment.

The first two spacecraft were deployed during the 1984 41-D and 51-A Shuttle missions. LEASAT 3 was deployed successfully in 1985 during mission 51-D but failed to activate. The satellite drifted in low-Earth orbit until a salvage and rescue mission was performed by the crew of mission 51-I in September 1985. Following a series of modifications by the Shuttle crew, LEASAT 3 was successfully deployed into its operational orbit. Also as part of mission 51-I, LEASAT 4 was successfully deployed from the orbiter. However, it did not go into operational service due to a spacecraft failure shortly after arrival at geosynchronous orbit.

Interface between the spacecraft and the payload bay is accomplished with a cradle structure. The cradle holds the spacecraft with its forward end toward the nose of the orbiter. Mounting the antennas on deployable structures allows them to be stowed for launch.

Five trunnions (four longeron and one keel) attach the cradle to the orbiter. Five similarly located internal attach points attach the spacecraft to the cradle.

# SYNCOM IV-F5

Another unique feature of the Syncom IV series of satellites is the lack of requirement for a separately purchased upper stage, as have all other communications satellites launched to date from the Shuttle.

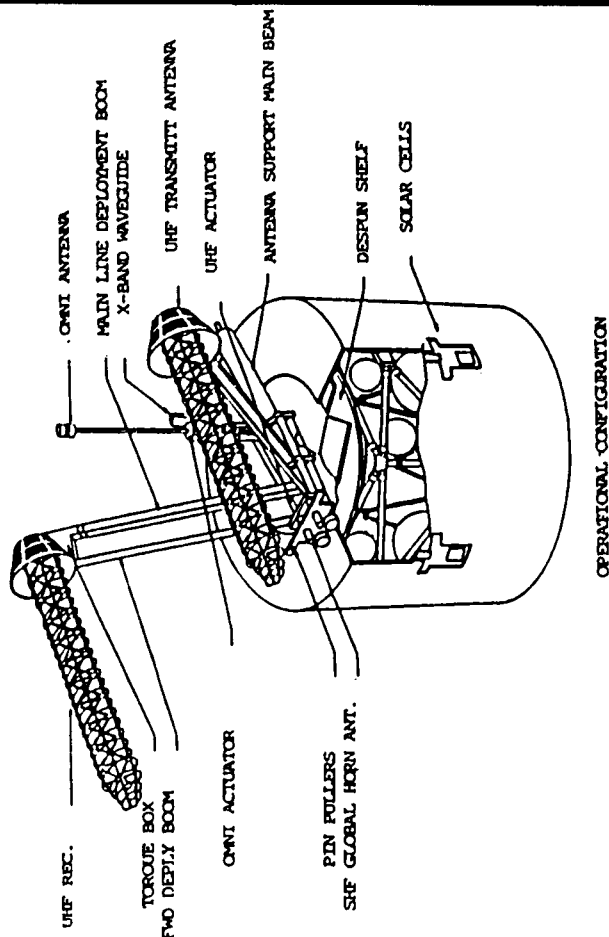
The Syncom IV satellites contain their own unique upper stage to transfer them from the Shuttle deploy orbit of about 160 nm to a circular orbit 19,300 nm over the equator.

Each satellite is 20 feet long with UHF and omnidirectional antennas deployed. Total payload weight in the orbiter is 17,000 pounds. The satellite's weight on station, at the beginning of its life, will be nearly 3,060 pounds. Hughes' Space and Communications Group builds the satellites.

Ejection of the spacecraft from the Shuttle is initiated when locking pins at the four contact points are retracted. An explosive device then releases a spring that ejects the spacecraft in a "Frisbee" motion. This gives the satellite its separation velocity and gyroscopic stability. The satellite separates from the Shuttle at a velocity of about 1.5 feet per second and a spin rate of about 2 rpm.

As part of this mission, Columbia must rendezvous with the Long Duration Exposure Facility (LDEF). As a result, the normal Syncom IV launch condition constraints were relaxed so that Columbia could launch at any time of day, any day of the year. This change resulted in modifications to the spacecraft to permit three different mission scenarios required to meet the spacecraft operational constraints for different launch windows.

The first mission scenario is the standard Syncom IV sequence controlled by the Post Ejection Sequencer (PES). In the PES mode, a series of maneuvers, performed over a period of several



days, will be required to place Syncom IV into its geosynchronous orbit over the equator. The process starts 80 seconds after the spacecraft separates from Columbia with the automatic deployment of the omnidirectional antenna. Forty-five minutes after deployment, the solid perigee kick motor, identical to that used as the third stage of the Minuteman missile, is ignited, raising the high point of the satellite's orbit to approximately 8,200 nm.

Two liquid fuel engines that burn hypergolic propellants, monomethyl hydrazine and nitrogen tetroxide, are used to augment the velocity on successive perigee transits, to circularize the orbit and to align the flight path with the equator.

The first of three such maneuvers raises the apogee to 10,500 nm, the second to 13,800 nm and the third to geosynchronous orbital altitude. At this point, the satellite is in a transfer orbit with a 160 nm perigee and a 19,300 nm apogee. The final maneuver circularizes the orbit at the apogee altitude.

In the second mission scenario, called the Sub Transfer Earth Orbit or SEO Mode, the post-ejection sequencer fires the perigee kick motor 45 minutes after ejection from the cargo bay, as in the PES mode. However, in the SEO mode, the perigee augmentation maneuvers are delayed for up to 20 days to optimize spacecraft performance. After this delay, the mission is identical to the PES mission.

In the third mission scenario, called Low Earth Orbit or LEO mode, the post-ejection sequencer does not fire the perigee kick motor. Instead, the spacecraft is stored in low-Earth orbit for up to 15 days, until the PKM firing constraints are met. The perigee kick motor is then fired by ground command. The subsequent mission is identical to the PES mission.

The selection of the optimal mission scenario for Syncom IV-F5 will depend on the launch day and window selected for LDEF retrieval. This should be known several weeks before launch, but can be changed as late as 11 hours before launch.

Hughes Communications, Inc. operates the worldwide LEASAT satellite communications system under a contract with the Department of Defense, with the U.S. Navy acting as the executive agent. The system includes four LEASAT satellites and the associated ground facilities. Users include mobile air, surface, subsurface and fixed ground stations of the Navy, Marine Corps, Air Force and Army. The satellites are positioned for coverage of the continental United States and the Atlantic, Pacific and Indian oceans. LEASAT 1, 2 and 3 occupy geostationary positions at 15 degrees West, 73 degrees East and 105 degrees West, respectively. LEASAT 5 will be positioned at 177 degrees W.

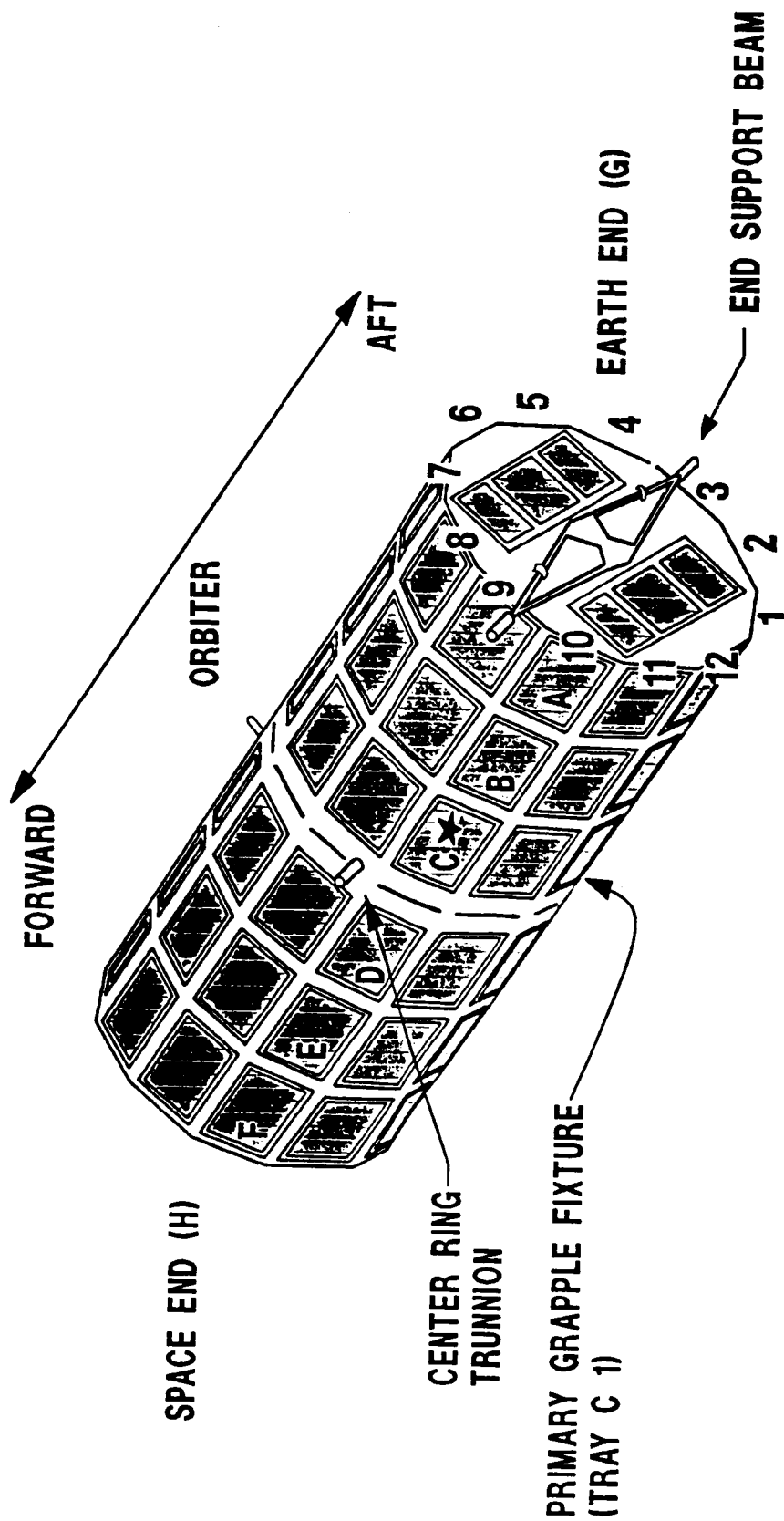
## LONG DURATION EXPOSURE FACILITY RENDEZVOUS AND RETRIEVAL

LDEF was delivered to Earth orbit by STS-41C (STS-13) on April 6, 1984. The orbiter Columbia will rendezvous and retrieve LDEF using a -R BAR approach and the remote manipulator system (RMS) for berthing of the spacecraft in the payload bay on flight day four.

### LDEF Rendezvous and Grapple

As the orbiter nears LDEF, the -R BAR approach will be initiated. The orbiter will first pass below the spacecraft and circle up and over it. The -R BAR approach is a new technique that does not require close-in fly-around. This maneuver will

# LONG DURATION EXPOSURE FACILITY



★ Secondary grapple fixture containing Experiment Initiate System (tray C 10)

face the payload bay toward Earth and LDEF will now be between, as well as perpendicular, to both the Earth and the orbiter.

At this point, Columbia is approximately 400 feet from LDEF with the RMS arm extended and the wrist camera pointing toward the orbiter's starboard side. The wrist camera will provide the primary field of view for grapple. A yaw maneuver then will be performed to place the wrist camera in the same x,y plane as grapple fixture 2 (GF2) aboard LDEF, so that the camera can eventually view GF2 head on.

LDEF is then directly "above" the crew compartment (the arm is still in its same position; unattached to the LDEF). This allows Commander Dan Brandenstein and Pilot Jim Wetherbee to make necessary flight instrument changes to "fly in formation" with the same speed and direction as the free-flying LDEF.

Next, the orbiter will move forward (+ZLV) very slowly. The crew will be watching their onboard monitor for the LDEF to appear in the wrist camera's field of view. As soon as GF2 is spotted, orbiter movement will cease. The wrist camera then will rotate 180 degrees to be properly positioned for the grapple of GF2.

Mission specialist Bonnie Dunbar then will direct the RMS toward GF2 and make the connection for grapple completion. LDEF will be approximately 35 feet above the bay during this procedure.

#### **LDEF Berthing**

The onboard computer then commands the arm to align LDEF with the berthing guides on the payload bay sides. The final

RMS maneuvering now will be commanded manually to set LDEF in the bay (if there are no failures, this process should take approximately 15 minutes).

The crew also will utilize the black and white camera positioned at keel station 3 aiming it at a docking target. The crew will be watching the on-board monitor with an overlay for precision berthing. Three orange styrofoam balls called "berthing whiskers" will extend horizontally inward from the forward payload bay side walls. The berthing whiskers will act as "curb feelers" to detect forward movement of LDEF.

#### **LDEF Post-Berthing**

The arm will now detach from GF2 and move to GF1, looking for the six Experiment Initiator System (EIS) indicators. If the EIS's are black, the experiments power supply is already off. If they are white, the arm will move into GF1 and turn off the experiments. Finally, the arm will be stowed.

#### **LDEF POST-FLIGHT**

STS-32 is a unique mission for payloads operations, as specialists must perform not only "up-processing" (i.e. pre-flight operations to prepare the Syncom IV payload for integration into the orbiter) but also a "down-processing" for 57 experiments that have been exposed to the harsh space environment for more than 5 years aboard the Long Duration Exposure Facility.

In supporting the return of LDEF, the KSC payload team, working closely with Langley Research Center, has planned a post-flight flow that accentuates the preservation of the scientific



data. In addition, special research teams from Langley, which sponsored the project, will be at KSC when LDEF returns.

LDEF will remain in Columbia's payload bay during routine post-flight servicing at Edwards Air Force Base, Calif. and during the ferry-flight back to KSC.

To assist in maintaining experiment integrity, an air-conditioned purge system will be hooked up to the orbiter during its stay at EAFB and any overnight stops. This system will keep air-conditioned air circulating through the payload bay.

Once Columbia is in the Orbiter Processing Facility (OPF), LDEF will be removed from the cargo bay and placed in a payload canister and transported to the Operations and Checkout Building (O&C). There, LDEF will be loaded from the canister to the LATs (LDEF Assembly and Transportation System). This special "cradle" is 55 feet long, 17 feet wide, and 21 feet high. LATs also was used during the pre-launch processing of LDEF.

LDEF is expected to be in the O&C from about Jan. 8-12. Then, supported by the LATs, it will be transferred to the Spacecraft Assembly and Encapsulation Facility, where the experiments will be taken off the frame and turned over to researchers.

#### **Post-Mission Operations**

At KSC, LDEF will be turned over to Langley personnel for off-line facility and experiment operations.

Before any experiment activities or operations begin, there will be an initial inspection of LDEF and its experiments to check the general condition of the spacecraft and to look for any unexpected changes.

Once the initial inspection is completed, all of the principal investigators (PI) and the Special Investigation Groups (SIG) will conduct detailed visual inspections of the entire LDEF and all of the visible experiment hardware.

Experiment trays will be removed from the LDEF and taken on ground support equipment transporters to an experiment operations area. After batteries are removed from once-active experiments, trays will go to a work bench where the PIs will perform closer inspections and take basic measurements. After the PIs have completed their procedures, the experiment hardware will be properly configured, packaged and shipped to the PIs' laboratories.

An accessible LDEF database will be developed to document all of the information resulting from the LDEF mission. It is anticipated that this unique body of data on space experiments and the effects of long-term exposure in space on typical spacecraft hardware will become a valued resource to future spacecraft designers. Structures like the LDEF provide a relatively inexpensive way to conduct experiments and may be reusable. Requirements for the use of the LDEF or similar facilities for follow-on flights will be evaluated at a later date.

#### **Structure**

LDEF is a 12-sided, open grid structure made of aluminum rings and longerons (fore-and-aft framing members). The structure is 30 feet long, 14 feet in diameter and weighs 8,000 pounds.

LDEF's center ring frame and end frames are of welded and bolted construction. The longerons are bolted to both frames, and intercostals (crosspieces between longerons) are bolted to the

longerons to form intermediate rings. The main load of LDEF was transmitted to the orbiter through two side-support trunnions on the center ring.

LDEF holds 86 experiment trays, 72 around the circumference, six on the Earth-pointing end and eight on the space-pointing end. A typical tray measures 50 inches by 34 inches and investigators could choose one of three depths: 3, 6 or 12 inches. The trays are made of aluminum and hold experiments that weigh up to 200 pounds. Some experiments fill more than one tray; some fill only part of a tray. All trays and their experiments weigh only 13,400 pounds. Total weight of the structure, trays and experiments is 21,393 pounds.

### Experiments

The LDEF experiments are divided into four groups: materials and structures, power and propulsion, science and electronics and optics. The 57 experiments on LDEF involve 200 investigators, who represent 21 universities, 33 private companies, seven NASA centers, nine Department of Defense laboratories and eight foreign countries.

LDEF science experiments include an interstellar gas experiment that may provide insight into the formation of the Milky Way galaxy by capturing and analyzing its interstellar gas atoms.

LDEF cosmic radiation experiments are designed to investigate the evolution of the heavier elements in our galaxy.

LDEF micrometeoroid experiments could increase understanding of the processes involved in the evolution of our Solar System. The impact of space radiation on living organisms

is another area investigated. LDEF science experiments gathered data on the radiation intensity and its effect on living organisms such as shrimp eggs and plant seeds.

Other LDEF experiments collected data on the behavior of a multitude of materials used to manufacture spacecraft and space experiment systems exposed to space, including radiation, vacuum, extreme temperature variations, atomic oxygen and collision with space matter. The LDEF mission has provided important information for the design of future spacecraft that will require extended lifetimes in space, such as Space Station Freedom.

Several LDEF experiments were designed to investigate the effects of prolonged exposure to the space environment on optical system components, which include optical filters, coatings, glasses, detectors and optical fiber transmission links. LDEF provided an opportunity to study the effects of long-term space exposure on the design of solar array power systems by investigating the effects of exposure to the space environment on a wide variety of solar cells and associated components.

A unique process for growing crystals in solutions, which took advantage of the microgravity conditions provided by LDEF, was used to grow high purity crystals with unique electrical properties applicable to electronic circuits.

The Space Exposed Experiment Developed for Students (SEEDS) offers a wide variety of opportunities for student experiments. Investigators will provide a total of 12.5 million tomato seeds, packaged in kits, to students from the upper elementary through the university level. Students will have the unprecedented opportunity to study the effects of long-term space exposure on tomato seeds. The program encourages active

student involvement and a multidisciplinary approach, allowing students to design their own experiments and to be involved in decision making, data gathering and reporting of final results.

The low cost of an LDEF experiment encouraged high-risk/high-return investigations and made experiments particularly attractive to students and research groups with no experience in space experimentation. Investigators could take advantage of NASA and private industry expertise to develop relatively inexpensive investigations.

The LDEF structure was designed and built at the Langley Research Center in Hampton, Va. Experiment trays were provided to investigators, who built their own experiments, installed them in trays and tested them. To help reduce costs, each investigator established the amount of reliability, quality control and testing required to insure proper operation of his experiment.

The LDEF project is managed by Langley for NASA's Office of Aeronautics and Space Technology in Washington, D.C. E. Burton Lightner is Manager of the LDEF Project Office. William H. Kinard is LDEF Chief Scientist and Head of the Data Analysis Team.

## AMERICAN FLIGHT ECHOCARDIOGRAPH

The American Flight Echocardiograph is an off-the-shelf medical ultrasonic imaging system modified for Space Shuttle compatibility. The AFE noninvasively generates a two-dimensional, cross-sectional image of the heart or other soft tissues and displays it on a cathode-ray tube (CRT) at 30 frames per second.

AFE has flown before on STS-51D and is designed to provide inflight measurements of the size and functioning of the heart and record heart volume and cardiovascular responses to space flight. Results from the AFE will be used in the development of optimal countermeasures to crew cardiovascular changes.

Operated by STS-32 Mission Specialist Marsha Ivins, the AFE hardware will be stored in an orbiter middeck locker. All five crew members will participate in the experiment as subjects as time allows. Crew members also will use the AFE to support Detailed Secondary Objective 478, the first flight of a collapsible Lower Body Negative Pressure unit.

In echocardiography, a probe next to the skin sends high frequency sound waves (ultrasound) through the skin and into the body, then detects reflections or echos from the surfaces of the organs, producing pictures.

The Life Sciences Division of NASA's Office of Space Science and Applications is sponsoring the AFE which was developed at the Johnson Space Center. Dr. Michael Bungo, the Director of JSC's Space Biomedical Research Institute, is the Principal Investigator.

## CHARACTERIZATION OF NEUROSPORA CIRCADIAN RHYTHMS

Characterization of Neurospora Circadian Rhythms (CNCR) in Space is a middeck payload sponsored by the Office of Space Science and Applications, Life Sciences Division. The objective of the CNCR experiment is to determine if neurospora (pink bread mold) circadian rhythm (diurnal cycles) persists in the microgravity environment of space.

This experiment is intended to provide information about endogenously driven biological clocks, which might then be applied to other organisms. Endogenous indicates the activity occurs within a single cell's outer membrane.

Neurospora grows in two forms, a smooth confluence of silky threads (mycelia) and cottony tufts of upright stalks tipped with tiny ball-shaped spores (conidia). When growing in a constant, completely uniform external environment, the neurospora mold cycles rhythmically from one growth form to the other. This cycle causes the mold to produce the ball-shaped spores on approximately 21-hour intervals. This interval is believed to be controlled by an internal cell clock.

However, under typical circumstances, alterations in the external environment, particularly day-night cycles with a period of 24 hours, are capable of readjusting the neurospora internal clock. The fundamental question addressed by this Shuttle experiment is whether the conditions of space flight, especially the absence of Earth's strong gravitational field, affect the neurospora's circadian rhythms. Because these rhythmic phenomena also are found in all plants and animals, including humans, this experiment addresses a broad and important biological question.

The Principal Investigator is Dr. James S. Ferraro, Southern Illinois University, Carbondale, Ill. Project Manager is Dr. Randall Berthold at NASA's Ames Research Center, Mountain View, Calif. Project Scientist is Dr. Charles Winget, also at Ames. Program Scientist/Manager is Dr. Thora Halstead, NASA Headquarters Life Sciences Division. Mission Manager is Willie Beckham of NASA's Johnson Space Center, Houston.

## PROTEIN CRYSTAL GROWTH EXPERIMENT

The Protein Crystal Growth (PCG) payload aboard STS-32 is a continuing series of experiments that may prove a major benefit to medical technology. These experiments could improve food production and lead to innovative new drugs to combat cancer, AIDS, high blood pressure, organ transplant rejection, rheumatoid arthritis and many other diseases.

Protein crystals, like inorganic crystals such as snowflakes, are structured in a regular pattern. With a good crystal, roughly the size of a grain of table salt, scientists are able to study the protein's molecular architecture.

Determining a protein crystal's molecular shape is an essential step in several phases of medical research. Once the three-dimensional structure of a protein is known, it may be possible to design drugs that will either block or enhance the protein's normal function within the body. Though crystallographic techniques can be used to determine a protein's structure, this powerful technique has been limited by problems encountered in obtaining high-quality crystals well-ordered and large enough to yield precise structural information.

Protein crystals grown on Earth are often small and flawed. The problem associated with growing these crystals is analogous to filling a sports stadium with fans who all have reserved seats. Once the gate opens, people flock to their seats and in the confusion, often sit in someone else's place. On Earth, gravity-driven convection keeps the molecules crowded around the "seats" as they attempt to order themselves. Unfortunately, protein molecules are not as particular as many of the smaller molecules and are often content to take the wrong places in the structure.

As would happen if you let the fans into the stands slowly, microgravity allows the scientist to slow the rate at which molecules arrive at their seats. Since the molecules have more time to find their spot, fewer mistakes are made, creating better and larger crystals.

During the STS-32 mission, 120 different PCG experiments will be conducted simultaneously using as many as 24 different proteins. Though there are three processes used to grow crystals on Earth—vapor diffusion, liquid diffusion and dialysis—only vapor diffusion will be used in this set of experiments.

Shortly after achieving orbit, either Mission Specialist Marshall or Mission Specialist David Low will combine each of the protein solutions with other solutions containing a precipitation agent to form small droplets on the ends of double-barreled syringes positioned in small chambers. Water vapor will diffuse from each droplet to a solution absorbed in a porous reservoir that lines each chamber. The loss of water by this vapor diffusion process will produce conditions in the droplets that cause protein crystals to grow.

In three of the 20-chambered, 15-by-10-by-1.5-inch trays, crystals will be grown at room temperature (22 degrees Centigrade); the other three trays will be refrigerated (4 degrees C) during crystal growth. STS-32 will be the first mission during which PCG experiments will be run at 4 degrees C, making it possible to crystallize a wider selection of proteins. The 9-day flight also provides a longer time period for crystals to grow.

A seventh tray will be flown without temperature control. The crew will videotape droplets in the tray to study the effects of orbiter maneuvers and crew activity on droplet stability and crystal formation.

Just prior to descent, the mission specialist will photograph the droplets in the room temperature trays. Then all the droplets and any protein crystals grown will be drawn back into the syringes. The syringes then will be resealed for reentry. Upon landing, the hardware will be turned over to the investigating team for analysis.

Protein crystal growth experiments were first carried out by the investigating team during Spacelab 2 in April 1985. These experiments have flown six times. The first four flights were primarily designed to develop space crystal growing techniques and hardware.

The STS-26 and STS-29 experiments were the first scientific attempts to grow useful crystals by vapor diffusion in microgravity. The main differences between the STS-26 and STS-29 payloads and those on previous flights were the introduction of temperature control and the automation of some of the processes to improve accuracy and reduce the crew time required.

To further develop the scientific and technological foundation for protein crystal growth in space, NASA's Office of Commercial Programs and the Microgravity Science and Applications Division are co-sponsoring the STS-32 experiments with management provided through Marshall Space Flight Center, Huntsville, Ala. Blair Herren is the Marshall experiment manager and Richard E. Valentine is the mission manager for the PCG experiment at Marshall.

Dr. Charles E. Bugg, director of the Center for Macromolecular Crystallography, a NASA-sponsored Center for the Development of Space located at the University of Alabama-Birmingham, is lead investigator for the PCG research team.

The STS-32 industry, university and government PCG research investigators include CNRS, Marseille, France; Eli Lilly & Co.; U.S. Naval Research Laboratory; E.I. du Pont de Nemours & Co.; Merck Sharp & Dohme Laboratories; Texas A&M University; University of Alabama-Birmingham/Schering Corp.; Yale University; University of Pennsylvania; University of California at Riverside; The Weizmann Institute of Science; Marshall Space Flight Center; Australian National University/BioCryst, Ltd.; University of Alabama-Birmingham/BiCryst; Smith Kline & French Labs.; The Upjohn Co.; Eastman Kodak Co.; Wellcome Research Labs. and Georgia Institute of Technology.

## MICROGRAVITY RESEARCH WITH THE FLUIDS EXPERIMENT APPARATUS

### Fluids Experiment Apparatus

The Fluids Experiment Apparatus (FEA) is designed to perform materials processing research in the microgravity environment of spaceflight. Its design and operational characteristics are based on actual industrial requirements and have been coordinated with industrial scientists, NASA materials processing specialists and Space Shuttle operations personnel. The FEA offers experimenters convenient, low-cost access to space for basic and applied research in a variety of product and process technologies.

The FEA is a modular microgravity chemistry and physics laboratory for use on the Shuttle and supports materials processing research in crystal growth, general liquid chemistry, fluid physics and thermodynamics. It has the functional capability to heat, cool, mix, stir or centrifuge gaseous, liquid or solid experiment samples. Samples may be processed in a variety

of containers or in a semicontainerless floating zone mode. Multiple samples can be installed, removed or exchanged through a 14.1-by-10-inch door in the FEA's cover.

Instrumentation can measure sample temperature, pressure, viscosity, etc. A camcorder or super-8mm movie camera may be used to record sample behavior. Experiment data can be displayed and recorded through the use of a portable computer that also is capable of controlling experiments.

The interior of the FEA is approximately 18.6-by-14.5-by-7.4 inches and can accommodate about 40 pounds of experiment-unique hardware and subsystems. The FEA mounts in place of a standard stowage locker in the middeck of the Shuttle crew compartment, where FEA is operated by the flight crew.

Modular design permits the FEA to be easily configured for almost any experiment. Configurations may be changed in orbit, permitting experiments of different types to be performed on a single Shuttle mission. Optional subsystems may include custom furnace and oven designs, special sample containers, low-temperature air heaters, specimen centrifuge, special instrumentation and other systems specified by the user. Up to 100 watts of 120-volt, 400-Hertz power is available from the Shuttle orbiter for FEA experiments. The FEA was successfully flown on two previous missions, as a student experiment on STS-41D and as the first flight of the JEA on STS-30.

Rockwell International, through its Space Transportation Systems Division, Downey, Calif., is engaged in a joint endeavor agreement (JEA) with NASA's Office Commercial Programs in the field of floating zone crystal growth and purification research. The 1989 agreement provides for microgravity experiments to be performed on two Space Shuttle missions.

Under the sponsorship of NASA's Office of Commercial Programs, the FEA will fly aboard Columbia on STS-32. Rockwell is responsible for developing the FEA hardware and for integrating the experiment payload. Johnson Space Center, Houston, has responsibility for developing the materials science experiments and for analyzing their results.

The Indium Corporation of America, Utica, N.Y., is collaborating with NASA on the experiments and is providing seven indium samples to be processed during this mission. NASA provides standard Shuttle flight services under the JEA.

### Floating Zone Crystal Growth and Purification

The floating zone process is one of many techniques used to grow single crystal materials. The process involves an annular heater that melts a length of sample material and then moves along the sample. As the heater moves (translates), more of the polycrystalline material in front of it melts. The molten material behind the heater will cool and solidify into a single crystal.

The presence of a "seed" crystal at the initial solidification interface will establish the crystallographic lattice structure and orientation of the single crystal that results. Impurities in the polycrystalline material will tend to stay in the melt as it passes along the sample and will be deposited at the end when the heater is turned off and the melt finally solidifies.

Under the influence of Earth's gravity, the length of the melt is dependent upon the density and surface tension of the material being processed. Many industrially important materials cannot be successfully processed on Earth because of their properties. In the microgravity environment of spaceflight, there is a maximum theoretical molten zone length which can be achieved.

Materials of industrial interest include selenium, cadmium telluride, gallium arsenide and others. Potential applications for those materials include advanced electronic electro-optical devices and high-purity feed stock. Zone refining to produce ultra-high purity indium also is of interest for the production of advanced electronic devices from indium antimonide and indium arsenide.

### FEA-3 Experiment Plan

The FEA-3 microgravity disturbances experiment involves seven samples (plus one spare) of commercial purity indium (99.97 percent purity). Indium was chosen for this experiment because it is a well-characterized material and has a relatively low melting point (156 degrees Celsius). The samples each will be 1 centimeter in diameter and 18 centimeters long and will be processed in an inert argon atmosphere. The sample seeding heater translation rates and process durations are provided in the following table:

Experiment Samples and Parameters			
Sample	Seeded	Heater Rate (cm/hour)	Duration (hours)
1	No	0	2.00
2	Yes	24	4.50
3	Yes	12	9.00
4	Yes	24	4.50
5	Yes	48	2.25
6	Yes	12	9.00
7	Yes	96	1.10



At 5.25 hours mission elapsed time (MET), the flight crew will unstow the FEA and connect its computer and support equipment. The samples will be sequentially installed at 20, 26, 44, 66, 97, 114 and 144 hours MET and processed.

The experiment parameters (heater power and translation rate) will be controlled by the operator through the FEA control panel. Sample behavior (primarily melt-zone length and zone stability) will be observed by the operator and recorded using the on-board camcorder. Experiment data (heater power, translation rate and position, experiment time, and various experiment and FEA temperatures) will be formatted, displayed to the operator and recorded by the computer. The operator will record the MET at the start of each experiment and significant orbiter maneuvers and other disturbances that occur during FEA operations. In addition, accelerometer measurements during the induced disturbances will be recorded for postflight analysis.

In general, the experiment process involves installing a sample in the FEA, positioning the heater at a designated point along the sample, turning on the heater to melt a length of the sample, starting the heater translation at a fixed rate and maintaining a constant melt-zone length. When the heater reaches the end of the sample, it is turned off, allowing the sample to completely solidify, and the heater's translation is reversed until it reaches the starting end of the sample. The sample 8mm camcorder cassette and computer disk with the experiment data then can be changed and the next experiment started.

### FEA-3 Experiment Description

Most materials are processed in space to take advantage of the low gravity levels achievable in low-Earth orbit, which has been demonstrated to produce superior quality crystals over those

grown on the ground. The focus of the FEA-3 experiment entitled "Microgravity Disturbances Experiment," is to investigate the effects of both orbiter and crew-induced disturbances in the microgravity environment on the resulting microstructure of float-zone-grown indium crystals.

The FEA-3 experiment is one of the first designed specifically to grow crystals during known disturbances to investigate their effects on crystal growth processes. The disturbances to be investigated in this experiment will focus on orbiter engine firings and crew exercise on the treadmill, but will include several other disturbances typical of orbiter operations. This research should provide information useful in establishing the microgravity-level requirements for processing materials aboard Space Station Freedom and also provide a greater understanding of the role of residual gravity in materials processing.

This experiment will also investigate the effects of disturbances on the stability of a freely suspended molten zone and provide information on the impurity refining capability of float zone processing in space.

## MESOSCALE LIGHTNING EXPERIMENT

Space Shuttle mission STS-32 will again carry the Mesoscale Lightning Experiment (MLE), designed to obtain nighttime images of lightning to better understand the global distribution of lightning, the relationships between lightning events in nearby storms and relationships between lightning, convective storms and precipitation.

A better understanding of the relationships between lightning and thunderstorm characteristics can lead to the development of



applications in severe storm warning and forecasting and in early warning systems for lightning threats to life and property.

In recent years, NASA has used the Space Shuttle and high-altitude U-2 aircraft to observe lightning from above convective storms. The objectives of these observations have been to determine some of the baseline design requirements for a satellite-borne optical lightning mapper sensor; study the overall optical and electrical characteristics of lightning as viewed from above the cloud top and to investigate the relationship between storm electrical development and the structure, dynamics and evolution of thunderstorms and thunderstorm systems.

The MLE began as an experiment to demonstrate that meaningful, qualitative observations of lightning could be made from the Shuttle. Having accomplished this, the experiment is now focusing on quantitative measurements of lightning characteristics and observation simulations for future space-borne lightning sensors.

Data from the MLE will provide information for the development of observation simulations for an upcoming polar platform and Space Station instrument, the Lightning Imaging Sensor. The lightning experiment also will be helpful for designing procedures for using the Lightning Mapper Sensor, planned for several geostationary platforms.

### The Experiment

The Space Shuttle payload bay camera will be pointed directly below the orbiter to observe nighttime lightning in large, or mesoscale, storm systems to gather global estimates of lightning as observed from Shuttle altitudes. Scientists on the ground will analyze the imagery for the frequency of lightning flashes in

active storm clouds within the camera's field of view, the length of lightning discharges and cloud brightness when illuminated by the lightning discharge within the cloud.

If time permits during missions, astronauts also will use a handheld 35mm camera to photograph lightning activity in storm systems not directly below the Shuttle's orbital track.

Data from the MLE will be associated with ongoing observations of lightning made at several locations on the ground, including observations made at facilities at the Marshall Space Flight Center, Huntsville, Ala.; Kennedy Space Center, Fla.; and the NOAA Severe Storms Laboratory, Norman, Okla. Other ground-based lightning detection systems in Australia, South America and Africa will be integrated when possible.

The MLE is managed by NASA's Marshall Space Flight Center. Otha H. Vaughan Jr., is coordinating the experiment. Dr. Hugh Christian is the project scientist and Dr. James Arnold is the project manager.

### IMAX

The IMAX project is a collaboration between NASA and the Smithsonian Institution's National Air and Space Museum to document significant space activities using the IMAX film medium. This system, developed by the IMAX Systems Corp., Toronto, Canada, uses specially designed 70mm film cameras and projectors to record and display very high definition large-screen color motion pictures.

IMAX cameras previously have flown on Space Shuttle missions 41-C, 41-D and 41-G to document crew operations in the payload bay and the orbiter's middeck and flight deck along with

spectacular views of Earth. Film from those missions form the basis for the IMAX production, *The Dream is Alive*.

In 1985, during Shuttle Mission STS-61-B, an IMAX camera mounted in the payload bay recorded extravehicular activities in the EASE/ACCESS space construction demonstrations.

So far in 1989, the IMAX camera has flown twice, during Shuttle missions STS-29 in March and STS-34 in October. During those missions, the camera was used to gather material for an upcoming IMAX production entitled *The Blue Planet*.

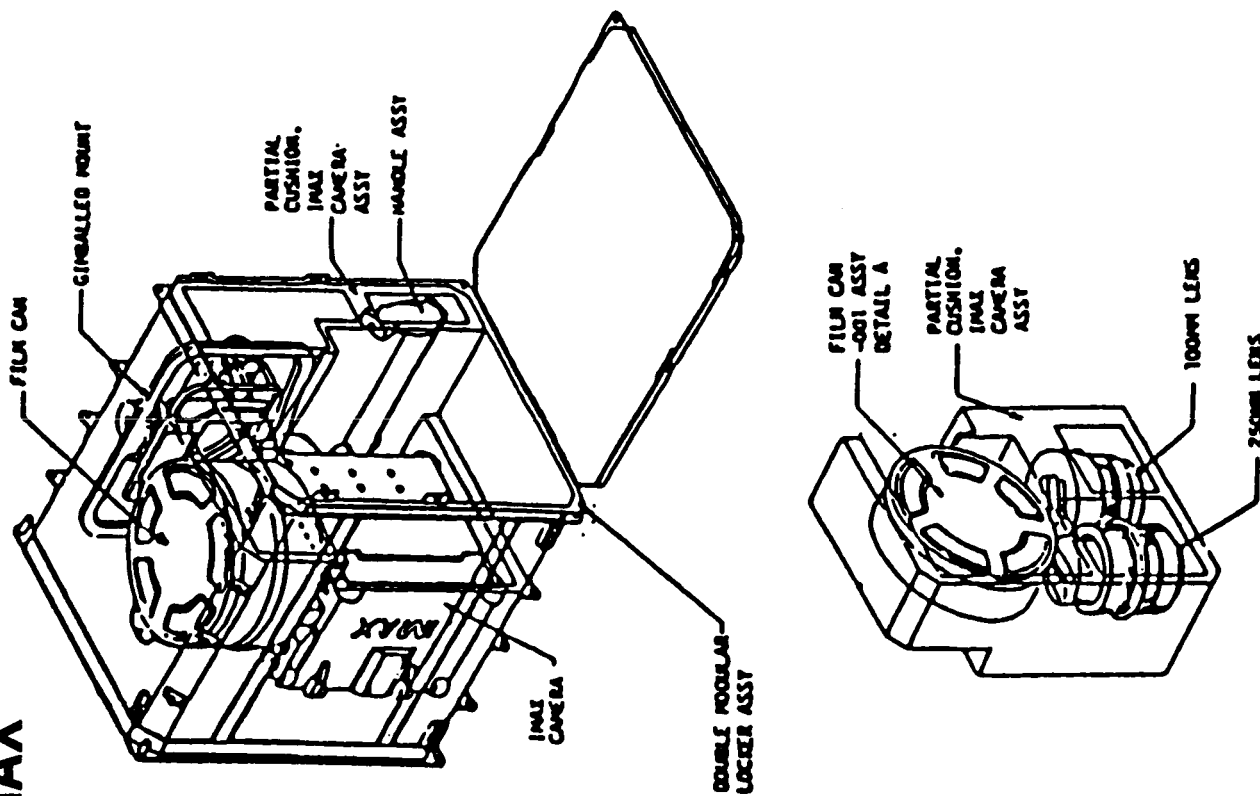
During STS-32, IMAX will film the retrieval of the Long Duration Exposure Facility and collect additional material for upcoming IMAX productions.

### AIR FORCE MAUI OPTICAL SITE CALIBRATION TEST (AMOS)

The Air Force Maui Optical Site (AMOS) tests allow ground-based electro-optical sensors located on Mount Haleakala, Maui, Hawaii, to collect imagery and signature data of the orbiter during overflights of that location. The scientific observations made of the orbiter while performing reaction control system thruster firings, water dumps or payload bay light activation, are used to support calibration of the AMOS sensors and the validation of spacecraft contamination models. The AMOS tests have no payload-unique flight hardware and only require that the orbiter be in a pre-defined attitude operations and lighting conditions.

The AMOS facility was developed by the Air Force Systems Command (AFSC) through its Rome Air Development Center,

## IMAX



Griffiss Air Force Base, N.Y., and is administered and operated by the AVCO Everett Research Laboratory in Maui. The principal investigator for the AMOS tests on the Space Shuttle is from AFSC's Air Force Geophysics Laboratory, Hanscom Air Force Base, Mass. A co-principal investigator is from AVCO.

Flight planning and mission support activities for the AMOS test opportunities are provided by a detachment of AFSC's Space Systems Division at Johnson Space Center. Flight operations are conducted at JSC Mission Control Center in coordination with the AMOS facilities located in Hawaii.

## LATITUDE-LONGITUDE LOCATOR EXPERIMENT

On Shuttle mission 41-G, Payload Specialist and oceanographer Scully Power observed numerous unusual oceanographic features from orbit but was unable to determine their exact locations for subsequent study. NASA, in conjunction with the Department of Defense, began work on an instrument that would be able to determine the precise latitude and longitude of objects observed from space.

The Latitude-Longitude Locator (L3) was developed and flown on a previous Space Shuttle mission. This flight will continue tests to determine the accuracy and usability of the system in finding the latitude and longitude of known ground sites.

L3 consists of a modified Hasselblad camera equipped with a wide-angle 40 mm lens, a camera computer interface developed by JSC engineers and a Graphics Retrieval and Information Display (GRID) 1139 Compass Computer.

Crew members will take two photographs of the same target at an interval of approximately 15 seconds. Information will be fed to the GRID computer, which will compute two possible locations. The crew, by knowing whether the target is north or south of the flight path, will be able to determine which of the two locations is correct and the target's latitude and longitude.

Andy Saulietis of NASA's Johnson Space Center is the Principle Investigator for the experiment.

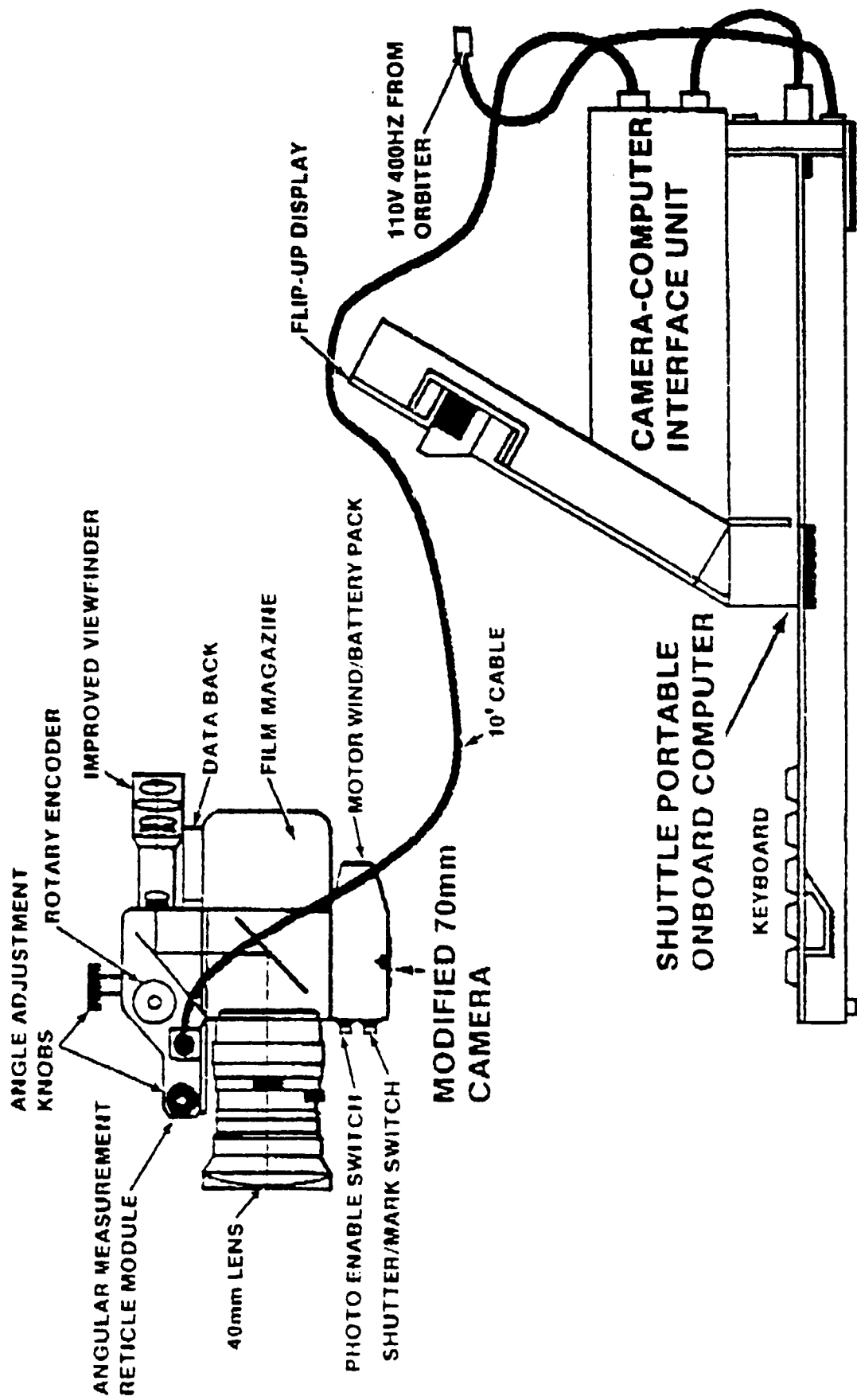
## SPACEFLIGHT TRACKING AND DATA NETWORK

Primary communications for most activities on STS-32 will be conducted through the orbiting Tracking and Data Relay Satellite System (TDRSS), a constellation of three communications satellites, two operational and one spare, in geosynchronous orbit 22,300 miles above the Earth. In addition, three NASA Spaceflight Tracking and Data Network (STDN) ground stations and the NASA Communications Network (NASCOM), both managed by Goddard Space Flight Center, Greenbelt, Md., will play key roles in the mission.

Three stations—Merritt Island and Ponce de Leon, Fla., and Bermuda—serve as the primary communications facilities during the launch and ascent phases of the mission. For the first 80 seconds, all voice, telemetry and other communications from the Space Shuttle are relayed to the mission managers at Kennedy and Johnson Space Centers by Merritt Island.

At 80 seconds, the communications are picked up from the Shuttle and relayed to the two NASA centers from Ponce de

# LATITUDE-LONGITUDE LOCATOR CONFIGURATION



Leon, 30 miles north of the launch pad. This facility provides the communications between the Shuttle and the centers for 70 seconds, or until 150 seconds into the mission. This is during a critical period when exhaust from the solid rocket motors "blocks out" the Merritt Island antennas.

Merritt Island resumes communications with the Shuttle after those 70 seconds and maintains communications until 6:30 after launch, when communications are "switched over" to Bermuda. Bermuda then provides the communications until 11 minutes after lift off when the TDRS-East satellite acquires the Shuttle. TDRS-West acquires the orbiter at launch plus 50 minutes.

Communications will alternate between the TDRS-East and TDRS-West satellites as the Shuttle orbits the Earth. The two satellites will provide communications with the Shuttle during 85 percent or more of each orbit. The TDRS-West satellite will handle communication with the Shuttle during its descent and landing phases.

## CREW BIOGRAPHIES

**Daniel C. Brandenstein**, 46, Capt. USN, will serve as commander. Selected as an astronaut in January 1978, he was born in Watertown, Wisc., and will be making his third Shuttle flight.

Brandenstein was pilot for STS-8, the third flight of Challenger, launched on Aug. 30, 1983. During the 6-day mission, the five-member crew deployed the Indian National Satellite (INSAT-1B) and tested the orbiter's remote manipulator system (RMS) with the Payload Test Article.

On his second flight, Brandenstein served as commander for STS-51G, launched June 17, 1985. During the 7-day mission, the 18th Space Shuttle flight, the seven-member crew deployed the Morelos satellite for Mexico; the Arabsat satellite for the Arab League; and the AT&T Telstar satellite. Also, the RMS was used to deploy and later retrieve the SPARTAN satellite.

Following STS-51G, Brandenstein became deputy director of flight crew operations at JSC and later assumed his current post, chief of the Astronaut Office.

He graduated from Watertown High School in 1961 and received a B.S. degree in mathematics and physics from the University of Wisconsin in 1965. Brandenstein was designated a naval aviator in 1967. During the Vietnam War and later as a test pilot, he logged more than 5,200 hours of flying time in 24 types of aircraft and has more than 400 carrier landings.

**James D. Wetherbee**, 37, Lt. Cmdr., USN, will serve as pilot. Selected as an astronaut in May 1984, he was born in Flushing, N.Y., and will be making his first Shuttle flight.

Wetherbee graduated from Holy Family Diocesan High School, South Huntington, N.Y., in 1970 and received a B.S. in aerospace engineering from Notre Dame in 1974.

Wetherbee was designated a naval aviator in December 1976. After serving aboard the aircraft carrier USS John F. Kennedy, he attended the Naval Test Pilot School and completed training there in 1981. He then worked with testing of, and later flew, the F/A-18 aircraft until his selection by NASA.

Wetherbee has logged more than 2,500 hours flying in 20 types of aircraft and completed more than 345 carrier landings.

**Bonnie J. Dunbar, 40**, will serve as mission specialist 1 (MS1). Selected as an astronaut in August 1981, she was born in Sunnyside, Wash., and will be making her second Shuttle flight.

Dunbar served as a mission specialist on STS-61A, the West German D-1 Spacelab mission and the first Shuttle flight to carry eight crew members. During the 7-day mission, Dunbar was responsible for operating the Spacelab and its subsystems as well as performing a variety of experiments.

Dunbar graduated from Sunnyside High School in 1967; received a B.S. degree and an M.S. degree in ceramic engineering from the University of Washington in 1971 and 1975, respectively; and received a doctorate in biomedical engineering from the University of Houston in 1983.

Dunbar joined NASA as a payload officer/flight controller at JSC in 1978. She served as a guidance and navigation officer/flight controller for the Skylab reentry mission in 1979, among other tasks, prior to her selection as an astronaut. She is a private pilot with more than 200 hours in single-engine aircraft and more than 700 hours in T-38 jets as a co-pilot.

**Marsha S. Ivins, 38**, will serve as mission specialist 2 (MS2). Selected as an astronaut in May 1984, she was born in Baltimore, Md., and will be making her first Shuttle flight.

Ivins graduated from Nether Providence High School, Wallingford, Pa., in 1969 and received a B.S. degree in aerospace engineering from the University of Colorado in 1973.

She began her career with NASA as an engineer in the Crew Station Design Branch at JSC in July 1974. Her work involved Space Shuttle displays and controls and development of the

orbiter head-up display. In 1980, Ivins became a flight simulation engineer on the Shuttle Training Aircraft and also served as a co-pilot on the NASA administrative aircraft, a Gulfstream I.

Ivins has logged more than 4,500 hours flying time in NASA and private aircraft and holds a multi-engine airline transport pilot license with a Gulfstream I rating; single-engine airplane, land, sea and commercial licenses; a commercial glider license; and instrument, multi-engine and glider flight instructor ratings.

**G. David Low, 33**, will serve as mission specialist 3 (MS3). Selected as an astronaut in May 1984, he was born in Cleveland and will be making his first Shuttle flight.

Low graduated from Langley High School, McLean, Va., in 1974; received a B.S. degree in physics-engineering from Washington and Lee University in 1978; received a B.S. degree in mechanical engineering from Cornell University in 1980; and received a M.S. degree in aeronautics and astronautics from Stanford University in 1983.

Low began his career with NASA in 1980 in the Spacecraft Systems Engineering Section of the NASA Jet Propulsion Laboratory (JPL), Pasadena, Calif., where he participated in the preliminary planning of several planetary missions and the systems engineering design of the Galileo spacecraft. Following a 1-year leave of absence from JPL to pursue graduate studies, he returned and worked as the principal spacecraft systems engineer for the Mars Geoscience/Climatology Observer Project until his selection as an astronaut.

As an astronaut, his technical assignments have included work with the RMS and extravehicular systems. He also served as a spacecraft communicator during STS-26, STS-27 and STS-29.

# NASA PROGRAM MANAGEMENT

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**James R. Thompson Jr.**  
NASA Deputy Administrator

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**George W.S. Abbey**  
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Acting Director, Space Shuttle Program  
Deputy Director, Space Shuttle Operations

**Leonard S. Nicholson**  
Deputy Director, Space Shuttle Program  
(located at Johnson Space Center)

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Director, Systems Engineering  
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**Gary E. Krier**  
Director, Operations Utilization

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Director, Unmanned Launch Vehicles  
and Upper Stages

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Associate Administrator for Safety,  
Reliability,  
Maintainability and Quality Assurance

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**John Loria**  
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Associate Administrator for Space Science  
and Applications

**A. V. Diaz**  
Deputy Associate Administrator for  
Space Science and Applications

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Director, Flight Crew Operations

**Eugene E. Kranz**  
Director, Mission Operations

**Henry O. Pohl**  
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**Charles S. Harlan**  
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Assurance

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Director

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**Jay E. Honeycutt**  
Director, Shuttle Management  
and Operations

**Robert B. Sieck**  
Launch Director

**George T. Sasseeen**  
Shuttle Engineering Director

**Larry Ellis (Acting)**  
Columbia Flow Director

**James A. Thomas**  
Director, Safety, Reliability and  
Quality Assurance

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Director, Payload Management  
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## Marshall Space Flight Center Huntsville, Ala.

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**Dr. J. Wayne Little**  
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**G. Porter Bridwell**  
Manager, Shuttle Projects Office  
Acting Manager, External Tank Project

**Dr. George F. McDonough**  
Director, Science and Engineering

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## NASA PROGRAM MANAGEMENT

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Manager, Solid Rocket Motor Project

**Cary H. Rutland**  
Manager, Solid Rocket Booster Project

**Jerry W. Smelser**  
Manager, Space Shuttle Main Engine Project

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**Frank Allario**  
Director for Electronics

**Leon Taylor**  
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**E. Burton Lightner**  
LDEF Project Manager

**William H. Kinard**  
LDEF Chief Scientist

**Charles Blankenship**  
Director for Structures

**Darrel Tenney**  
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**Gerald W. Smith**  
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**Ames Research Center**  
Mountain View, Calif.

**Dr. Dale L. Compton**  
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**Ames-Dryden**  
**Flight Research Facility**  
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Site Manager

**Theodore G. Ayers**  
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**Thomas C. McMurtry**  
Chief, Research Aircraft Operations Division

**Larry C. Barnett**  
Chief, Shuttle Support Office

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Greenbelt, Md.

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**Peter Burr**  
Director, Flight Projects

**Dale L. Fahnestock**  
Director, Mission Operations and Data Systems

**Daniel A. Spintman**  
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**Wesley J. Bodin**  
Associate Chief, Ground Network

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